LINEAR TABLE AND SIMPLIFIED ASSEMBLY METHOD

CROSS-REFERENCE TO RELATED CASES

The present application claims the benefit of the filing date of U.S. Provisional Application Serial No. 60/409,118; filed September 6, 2002, and U.S. Provisional Application Serial No. 60/438,622; filed January 6, 2003, the disclosures of which are expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates generally to linear tables, and to methods for accurately assembling such tables such that the tables have smooth and precise movement.

Linear tables generally have a flat slide plate useful for attaching devices or machines requiring linear movement; a base or bed which is fixed to a support surface; and a bearing structure located between the plate and base which supports the plate for controlled linear movement. A variety of bearing technologies exist that provide support and motion for such tables, including but not limited to square rail bearings, round rail bearings, ball/rail arrangements, and cross roller bearings.

The last of these, cross roller bearings, have achieved widespread acceptance as a technology which provides smooth, precise movement of the slide plate for a linear table in a variety of applications. Each cross roller bearing assembly includes a pair of bearing

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ways and a rolling element incorporating one or more ball bearings, rollers, etc. The rolling element(s) can be incorporated into a cage, holder or bracket, or in some cases it is loosely retained between the bearing ways. One bearing way is attached to the slide plate, the other bearing way is attached to the base, and the rolling element is located between the two ways. It is also known to incorporate the rolling element integral with (fixedly secured to) or unitary (in one piece) with one of the bearing ways. Two or more bearing assemblies, in parallel, spaced-apart relation, are typically used to support the slide plate for linear movement.

As is well known, the accuracy of assembly of the plate and base is an important factor for the correct performance of the linear table. Yaw, pitch and flatness are critical considerations in many applications. To accurately position the bearing ways under proper pre-load so that the slide plate has smooth movement, the ways are initially loosely secured such as with mounting screws to the base and the slide plate, with the rolling element(s) properly positioned between the ways. To facilitate the assembly, the plate and base conventionally have outwardly-projecting shoulders or other geometry extending along the length of the plate and base. The bearing ways are initially located against this geometry to properly align the ways on the table. The outer bearing way is then maneuvered with a series of pre-load screws (or some other integral device) supported and extending laterally through at least one of the shoulders until the proper pre-load along the length of the way is achieved. The mounting screws are then fully tightened to fixedly secure the ways to the plate and base.

Variations in the above assembly technique are known. For example, it is also known to fully tighten the mounting screws for one or more of the ways prior to adjusting the pre-load screws for the other way. In addition, fasteners other than screws, such as bolts, clamps, adhesive, etc., are also known to securely fix the ways to the slide plate and base.

As should be appreciated from the above discussion, the preload screws are adjusted during assembly in order to properly preload the bearing ways, and thereby provide smooth and precise movement of the linear table. This includes adjusting (and

sometimes re-adjusting) the individual preload screws along the length of each way, and using tools such as height gauges, dial indicators and custom gages to confirm the accuracy of the alignment. This complicates assembly, and increases the cost of the linear table. It also increases the risk of misalignment. The slide plate and base must also be accurately manufactured, with carefully-formed shoulders or other geometry for locating the ways. The shoulders and adjacent surface of the plate/base are typically flat and precisely perpendicular. The ways must also be accurately manufactured, with corresponding flat, perpendicular adjacent side surfaces to match the surfaces of the plate and base. The precision and straightness of the surfaces on the plate and the base, as well as the surfaces on the ways, is critical for the accurate installation of the bearing ways in the linear table. The base and plate must also be wide enough to support such shoulders, which increases the over-all size (width) of the linear table. In all, it is incumbent on the manufacturer to spend significant time and effort forming these components, which as can be appreciated, also increases the cost of the linear table.

Thus, it is believed there is a demand in the industry for a new and useful linear table, and a method for assembling such a linear table, which is accurate, simplified, and relatively easy, so that the linear table has smooth and precise operation.

SUMMARY OF THE INVENTION

The present invention provides a new and useful linear table, and a method for assembling a linear table, which is accurate, simplified and relatively easy, such that the linear table has smooth and precise movement. The linear table does not require integral bearing way shoulders or preload screws, which simplifies manufacturing and assembly of the table, and reduces costs. The linear table can also be narrower, as the base and plate do not have to support such shoulders.

According to the present invention, the linear table includes a slide plate, a base, and sets of bearings assemblies to allow relative movement between the slide plate and base. Each bearing assembly includes an outer bearing way, an inner bearing way and a rolling element located between the bearing ways. The inner and outer bearing ways

have flat mounting surfaces which are located flush against corresponding flat mounting surfaces on the slide plate and base, and secured thereto with sets of fasteners extending through the plate and base. There are no locating shoulders or other such geometry on the slide plate or base, and the bearing ways can be located along the edges of the plate and base. Likewise, there are no preload screws or other integral preload device on the slide plate or base.

The alignment and preload on the bearing assemblies is accomplished using a separate and removable precision parallel device and preload fixture. According to a first example of the method for assembling the linear table, the bearing ways in each bearing assembly are initially loosely secured to the slide plate and the base, and the precision parallel device is located between the inner ways to locate the inner ways in precise parallel alignment with each other and with the base. The slide plate is then mounted to the base, with the rolling elements located between the inner and outer ways. The preload fixture has a tool such as a pair of jaws, with at least one of the jaws being moveable. The jaws are located outwardly from the outer bearing ways and are then compressed together, thereby compressing each outer way against the rolling element, inner way, and against an outer side edge of the precision parallel device, until a predetermined lateral preload is achieved. The first and second sets of fasteners are then tightened down to fixedly secure the inner ways to the base and the outer ways to the slide table. The jaws of the preload fixture are then released, the preload fixture is removed from around the outer bearing ways, and the precision parallel device is removed from between the inner bearing ways.

According to another example, the precision parallel device is located outwardly from the outer ways to locate the outer ways in precise parallel alignment with each other and with the base. The slide plate is then mounted to the base, with the rolling elements located between the inner and outer ways. The jaws of the preload fixture are located between the inner bearing ways and are then expanded, thereby compressing each inner way against the rolling elements, outer way, and against an inner side edge of the precision parallel device, until the predetermined lateral preload is achieved. The

fasteners are then tightened down to fixedly secure the inner ways to the base and the outer ways to the slide table.

Other examples of the method are to individually align and secure either the inner bearing ways to the base or the outer bearing ways to the slide plate using the precision parallel device and preload fixture; and then preloading and securing the remaining bearing ways in each set against the fixed bearing way using the preload fixture.

The linear table and the method for assembling such a table of the present invention is accurate, simplified, and relatively easy, so that the linear table has smooth and precise operation. The linear table and method require fewer screws than in known prior designs, and specifically, do not require "pre-load screws" or a similar preload device, as the preload is a function of the controlled movement and force of the fixture jaws against the precision parallel device. The linear table also does not require bearing way shoulders or other integral alignment or locating devices, as the initial alignment of the bearing assemblies is accomplished with the precision parallel device. The table can also be narrower, as the base and slide plate do not have to have additional width to support the locating shoulders. As such, the manufacture of the table is simplified, and assembly is facilitated. The risk of misalignment is also reduced.

Further features of the present invention will become apparent to those skilled in the art upon reviewing the following specification and attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an elevated perspective view of a linear table constructed according to the principles of the present invention;

Figure 2 is a top view of the linear table of Figure 1;

Figure 3 is a cross-sectional end view of the table taken substantially along the plane described by the lines 3-3 of Figure 2;

Figure 4 is an enlarged view of a portion of the table of Figure 3, with the rolling element removed;

Figure 5 is a cross-sectional side view of the linear table illustrating the method of

assembly of the table according to a first example of the present invention;

Figure 6 is a cross-sectional side view of the linear illustrating the method of assembly of the table according to a second example of the present invention;

Figure 7 is a cross-sectional side view of the linear table illustrating a first step of assembly according to a third example of the present invention;

Figure 8 is a cross-sectional side view of the linear table illustrating a first step of assembly according to a fourth example of the present invention;

Figure 9 is a cross-sectional side view of the linear table illustrating a second step of assembly in either the third or fourth examples of the present invention;

Figure 10 is a cross-sectional side view of the linear table illustrating a first step of assembly according to a fifth example of the present invention;

Figure 11 is a cross-sectional side view of the linear table illustrating a first step of assembly according to a sixth example of the present invention; and

Figure 12 is a cross-sectional side view of the linear table illustrating a second step of assembly in either the fifth or sixth examples of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, and initially to Figures 1-4, a linear table constructed according to the present invention is indicated generally at 14. The linear table 14 includes a lower base or bed 18; a top slide plate 20; and a pair of roller bearing assemblies, indicated generally at 22, 23. The base 18 has an essentially flat, upwardly-facing mounting surface 24, while the slide plate has an opposed, essentially flat, downwardly-facing mounting surface 25. It is noted that these surfaces can be oriented in a manner other than "up" or "down" depending upon the orientation of the linear table, and these and other similar descriptive terms are used throughout only to designate the relative relation of these components. It should also be appreciated that these surfaces can be other than completely flat, e.g.., they can have grooves or channels or other structure and geometry as appropriate for the linear table (such as to support a linear motor mounted between the base and slide plate). But as will be described below, the

surfaces do not have conventional "shoulders" or other geometry providing lateral support for the bearing assemblies, and as such the term "essentially flat" is intended to describe a surface of the slide table and/or base which is for the most part flat and continuous across the entire extent of the table and/or base, and does not include such shoulders.

In any case, the roller bearing assemblies 22, 23 are spaced apart, in precise parallel relation and each preferably extends along the entire length of the table. The roller bearing assemblies are preferably the same, with each having a first (inner) way 30 attached to the base 18; a second (outer) way 32 attached to the slide plate; and a rolling element 33, located between the first and second bearing ways 30, 32. The outer bearing ways 32 are typically located along opposite side edges 34 of the slide plate, although they could also be spaced somewhat inwardly or outwardly from the edges. The inner bearing ways 30 could alternatively be attached to the slide plate 20, while the outer bearing ways 32 could be attached to the base 18.

The bearing ways within each assembly are also preferably identical, or at least similar in structure. Referring to Figure 4, which shows the rolling element removed from bearing assembly 22 to facilitate understanding, each bearing way, for example inner bearing way 30, comprises an elongated square or rectangular component in cross-section, having a lower flat mounting surface 35 for mounting flush against the flat mounting surface 24 of the base; a V-shaped groove 36 in one (outwardly-facing) adjacent side surface facing the opposite bearing way for receiving and supporting a portion of the rolling element; and an opposite (inwardly-facing) flat side surface 37. The outer bearing way 32 likewise comprises an elongated square or rectangular component in cross-section, with a flat upper mounting surface 38 for mounting flush against the flat mounting surface 25 of the slide plate; a V-shaped groove 39 in one (inwardly-facing) side surface facing the opposite bearing way for receiving and supporting a portion of the rolling element; and an opposite (outwardly-facing) flat side surface 40.

Both the slide plate and base can have a short rib 41 with a planar outer surface

and preferably the same width as the respective bearing way. The flat mounting surface of the bearing way can be located flush against the planar surface of the rib to facilitate locating the bearing ways on the slide plate and the base and to space the bearing ways somewhat from the opposing surfaces to prevent binding or catching.

The rolling element 33 is preferably an elongated component, extending along at least a significant portion of the bearing ways, and including a cage enclosing one or more bearing components (e.g., ball bearings, rollers, etc), as should be known to those skilled in the art. The rolling elements 33 are located between the inner and outer ways 30, 32 in each bearing assembly to allow smooth linear movement of the slide plate 20 with respect to the base 18.

The roller bearing assemblies described above are generally of the "cross roller bearing" type, and typically include ball bearings supported in an elongated cage, where the ball bearings roll or glide between the grooves formed in the opposing ways, as should be well-known to those skilled in the art. Bearing assemblies of this type are commercially-available from a variety of sources, for example IKO Nippon Thompson Co., Ltd. of Tokyo, Japan. It is noted that this is only one type of roller bearing appropriate of the present invention. Other types include, but are not limited to, ball/rail arrangements or ballslide tables, or generally any other type of linear bearing that conventionally requires locating shoulders and/or preload method integral to the linear stage components.

Referring again to Figures 1-4, a first set of fasteners 42 (e.g., mounting screws) extend through throughbores 43 formed in the inner ways 30, and into threaded bores 44 formed in base 18. Throughbores 43 and 44 are formed vertically/axially through the inner way and base, that is, perpendicular to the respective mounting surfaces 35 and 24. The heads of screws 42 are fully received in counterbores of throughbores 43 such that they do not bind or catch on the inner surface of slide plate 20. Throughbores 45 in the slide plate 20 provide access for tools (e.g., a hex wrench) to tighten fasteners 42 when the slide plate 20 is appropriately linearly positioned with respect to base 18. A second set of similar fasteners 47 extend through throughbores 49 formed in the slide plate 20,

and into threaded bores 50 formed in the outer ways 32. Throughbores 49 and 50 are also preferably formed vertically/axially through the outer way and slide plate, and the heads of screws 47 likewise are fully received in counterbores of throughbores 49. The fasteners 42, 47 are preferably evenly-spaced along the length of the bearing ways. While three such fasteners are shown for each of the inner way and outer way in each bearing assembly (see, e.g., Figure 1), the number and location of the fasteners can vary depending upon the particular application.

Base 18 can be attached to a support surface in an appropriate manner, such as by fasteners extending through appropriate bores (not shown) formed in the base; while a device or machine to be moved is mounted to the outer (upper) surface 54 of the slide plate and fastened thereto such as with fasteners extending through threaded bores 56 and/or bores 45.

It is noted that while screws are shown in the figures, other techniques can be used to mount the bearing assemblies to the slide table and the base 18, such as bolts, adhesive, clamping devices, etc.

As should be appreciated from the above description of the bearing ways, there are no "pre-load screws" or other integral preload devices; or any "bearing shoulders" or other linear bearing locating features, necessary with the linear table of the present invention. Rather, the present invention eliminates the need for these elements while still accurately and easily assembling the linear table. Each bearing way is supported only by a flat, lateral surface flush against an opposing flat, lateral surface of the slide plate or base, and secured thereto only with the use of fasteners extending vertically/axially through the plate and base.

To this end, referring now to Figures 5-12, a method for assembling the linear table of Figures 1-4 is shown. According to this method, a precision parallel device is used to accurately position the bearing ways on each side of the table, and a fixture with a moveable tool is then used to apply a predetermined preload on the bearing assemblies. The bearing ways of each assembly can be secured at the same time, or individually in succession, using this method.

Referring to Figure 5, a first example of the method is shown. The bearing ways 30, 32 of each bearing assembly are initially loosely secured to the slide plate 20 and base 18 with fasteners 42 and 47, and the rolling element 33 is located therebetween. If the rolling element is not as long as the length of the bearing ways (which is typically the case), one or more "dummy" or removable rolling elements can also be inserted between the ways to hold the distance along the entire length of the ways. A precision parallel device, indicated generally at 60, is then inserted between the inner bearing ways 30. The precision parallel device includes outer flat side edges 69 oriented in precise parallel relation to each other, with a dimension (height) sufficient to engage flush against the inner side surfaces 37 of the inner bearing ways, and thereby provide fixed reference surfaces for the bearing ways. The precision parallel device can be any device appropriate for the particular application, such as a block, movable wedge, etc., and preferably has a structure that can be easily retracted after the linear table is assembled. Preferably the precision parallel device 60 has a height sufficient to fit closely between the ribs 41 supporting the inner bearing ways, and as such, the ribs 41 facilitate the placement of the precision parallel device relative to the base such that the bearing ways, and hence the bearing assemblies, are properly aligned on the table.

A preload fixture, indicated generally at 70, is then located outwardly from the outer bearing ways. The preload fixture includes a tool such as a pair of opposed jaws 72, 74, with elongated flat side edges 75, 76, respectively, having a dimension (height) sufficient to engage flush against the outer side surfaces 40 of the outer bearing ways. At least one of the jaws is moveable toward the other, and typically one of the jaws is fixed to a base, while the other jaw can be moved toward and away from the fixed jaw, using e.g., a toggle clamp, hydraulic cylinder, solenoid, or other appropriate device. The jaws 72, 74 are preferably continuous, elongated members which engage along the entire, or substantially the entire, length of the bearing ways; however, each jaw could alternatively have separate jaw members (e.g., plate pieces, screws, etc.) which would individually engage the side surfaces of the bearing ways and achieve the same result.

In any case, the jaws of the preload fixture are compressed laterally together to

compress the outer ways, rolling elements and inner ways against the outer side edges 69 of the precision parallel device 60. The jaws are compressed until a predetermined lateral preload is achieved in each bearing assembly. At this point the first and second set of fasteners 42, 47 are tightened down to an appropriate torque to fixedly secure the inner and outer ways to the base and slide plate. The bores 43, 49 in the inner bearing way and the slide plate have sufficient clearance to allow slight lateral movement of the associated bearing way until the appropriate preload is achieved and the fasteners are tightened down.

Appropriate tools can be used to confirm the preload of the bearings, or an electronic circuit can be provided to provide the preload reading to a remote reading device (not shown) or computer. Alternatively, if the geometry of the slide plate is held to close enough tolerances, the jaws of the preload fixture can be located to engage the outer side surfaces 34 of the slide plate when the bearings are properly preloaded.

The jaws of the preload fixture are then released and the linear table 14 is removed from the fixture 70, with the bearing assemblies under proper pre-load. The precision parallel device 60 is then removed from between the bearing assemblies and re-used. It is also possible that the precision parallel device could be left between the bearing assemblies during normal use of the table. Any "dummy" rolling elements are then also removed.

Alternatively, if the rolling elements only extend along a portion of the length of the bearing ways, which again, is typically the case, the precision parallel device and preload fixture can be used in steps, that is, applied only against the portion of the bearing ways with a rolling element located therebetween, wherein the fasteners at that particular portion can then be tightened; and then the precision parallel device and/or preload fixture can be shifted to another location along the bearing assembly, and the rolling element can be likewise shifted, and the next portion of the bearing assembly can then be properly secured to the table and base under proper preload. This can be repeated along the entire length of the ways until the entire bearing assemblies are under proper preload and secured to the base and table.

When assembled as described above and properly tightened, the bearing assemblies will be accurately positioned along the linear table such that the table has smooth and precise linear movement.

A second example of the mounting method is shown in Figure 6. In this example, the bearing ways are again initially loosely secured to the slide plate and base, with the rolling elements located therebetween. A precision parallel device is then located outwardly of the outer bearing ways 32 of the bearing assemblies, while a preload fixture is located between the inner bearing ways 30. Specifically, a precision parallel device, indicated generally at 80, is shown as including a pair of opposed fixed members 81, 82, each of which has an elongated flat inner side edge 83, 84, respectively, in precise parallel relation with one another and configured to engage flush against the outer side surface 40 of an outer way. Again, the precision parallel device 80 can be any device appropriate for the particular application, and preferably has a structure that can be expanded after the bearing ways are fixedly secured for removal from the linear table. The precision parallel device 80 is preferably located in slightly overlapping relation with the outer side surfaces 34 of the slide plate such that the precision parallel device is properly positioned relative to the table.

A preload fixture, indicated generally at 85, is then inserted between the inner bearing ways 30. The preload fixture includes a tool with a pair of jaws 86, 87, at least one of which is moveable, with outer flat side edges 88, 89, respectively, with a dimension (height) sufficient to engage flush against the inner side surfaces 37 of the inner bearing ways. The jaws of the preload fixture are expanded to compress the inner ways, rolling elements and outer ways against the fixed members 81, 82 of the precision parallel device 80. The jaws 86, 87 of the preload fixture are expanded until a predetermined lateral preload is achieved in each bearing assembly, after which the first and second set of fasteners 42, 47 are tightened down to an appropriate torque to fixedly secure the inner and outer ways to the base and slide plate. If the geometry of the base is held to close enough tolerances, the jaws can be located to engage the inside surface of the raise rib 41 when the bearings are properly preloaded.

Still further examples of the method are shown in Figures 7-12. In these examples, the bearing ways are each individually and sequentially secured to the slide plate and base, rather than being installed together and fastened at the same time, as in the examples of Figures 5 and 6. Specifically, as shown in Figures 7 and 8, the inner bearing way 30 of each bearing assembly is initially loosely secured to the base 18. In Figure 7, a precision parallel device, indicated generally at 90, is inserted between the inner bearing ways 30; while in Figure 8, the precision parallel device 90 includes a pair of fixed members 92, 93, located outwardly of the inner bearing ways 30. The precision parallel devices 90 are preferably the same as described above, and include parallel, flat side edges which engage flush against corresponding side edges of the inner or outer bearing ways.

A preload fixture, indicated generally at 95, with a pair of jaws 96, 97, at least one of which is moveable, is then used to correctly position the inner bearing ways. In Figure 7, the preload fixture is located outwardly from the inner bearing ways 30; while in Figure 8, the preload fixture is located inwardly, between the inner bearing ways 30. The jaws of the preload fixture are compressed together (Figure 7) or expanded (Figure 8) to compress the inner ways against the precision parallel device 90. The jaws are expanded until the inner ways are properly positioned with respect to the base, after which the first set of fasteners 42 are tightened down to an appropriate torque to fixedly secure the inner ways to the base 18.

With the inner bearing ways 30 fixedly secured to the base, the outer ways 32 can then be loosely tightened to the slide plate 20, and the slide plate can be mounted over the base with the rolling elements 33 located between the respective bearing ways. Next, as shown in Figure 9, the outer ways 32 are secured to the slide plate 20 using the preload fixture, indicated generally at 100, located outwardly from the outer bearing ways. As before, the preload fixture includes a pair of opposed jaws 102, 104, at least one of which is moveable. The jaws 102, 104 are compressed together to compress the outer ways and rolling elements against the fixed inner ways 30. The jaws are compressed until a predetermined lateral preload is achieved in each bearing assembly, after which the

second set of fasteners 47 are tightened down to an appropriate torque to fixedly secure the outer ways to the slide plate.

Alternatively, as shown in Figures 10-12, the outer bearing ways 32 can be initially positioned and fixedly secured to the slide plate 20, and then the inner bearing ways 30 can be preloaded against the outer bearing ways. Specifically, as shown in Figures 10 and 11, the outer bearing way 32 of each bearing assembly is initially loosely secured to the slide plate 20. In Figure 10, a precision parallel device, indicated generally at 110, is inserted between the outer bearing ways 32; while in Figure 11, the precision parallel device 110 includes a pair of fixed members 112, 113, and is located outwardly of the outer bearing ways 32. The precision parallel devices 110 are preferably the same as described above, and include parallel, flat side edges which engage flush against corresponding side edges of the inner or outer bearing ways.

A preload fixture, indicated generally at 115, with a pair of jaws 116, 117, at least one of which is moveable, is then used to correctly position the outer bearing ways. In Figure 10, the preload fixture 115 is located outwardly from the outer bearing ways 32; while in Figure 11, the preload fixture 115 is located between the outer bearing ways. The jaws of the preload fixture are compressed together (Figure 10) or expanded (Figure 11) to compress the outer ways against the precision parallel device 110. The jaws are compressed or expanded until the outer bearing ways are properly positioned with respect to the slide plate 20, after which the second set of fasteners 47 are tightened down to an appropriate torque to fixedly secure the outer ways to the slide plate.

With the inner bearing ways 32 fixedly secured to the slide plate, the inner bearing ways 30 can then be loosely tightened to the base 18, and the base can be mounted under the slide plate with the rolling elements 33 located between the respective bearing ways. Next, as shown in Figure 12, the inner ways 30 are secured to the base 18 using a preload fixture, indicated generally at 120, located between the inner bearing ways 30. As before, the preload fixture includes a pair of opposed jaws 122, 124, at least one of which is moveable. The jaws of the preload fixture are expanded to compress the inner ways 30 and bearings against the outer ways 32. The jaws are expanded until a

predetermined lateral preload is achieved in each bearing assembly, after which the first set of fasteners 43 are tightened down to an appropriate torque to fixedly secure the inner ways to the base 18.

In the examples of Figures 7-12, the preload fixture and precision parallel device are typically removed after all the fasteners have been fully tightened down, although as indicated previously, the precision parallel device can be left in the table during normal use. Also, while the precision parallel device can be removed prior to the steps of Figures 9 and 12, as one of the bearing ways is fixedly secured to the table at this point, the precision parallel device can also be retained for these steps, if desired. It is also noted that, with respect to the examples of Figures 7-12, the same preload fixture can be used to properly align the first inner or outer bearing way, while the first bearing way is secured to the respective slide plate or base; as is used to then preload the remaining bearing way against the fixed bearing way. This reduces the manufacturing tools necessary to assemble the linear table. Of course, two different preload fixtures could also be used, if desired.

It is also noted that since the precision parallel device or preload fixture in the steps shown in Figures 7, 8, 10 and 11 is being applied to the groove side of the bearing way, it may be necessary or desirable to insert a "dummy" or expendable bearing way between the secured bearing way, with the groove in the "dummy" bearing way facing the groove in the secured bearing way, in order to prevent deformation of the secured bearing way during the preload step. In other words, in not all instances is the precision parallel device or preload fixture applied directly against the corresponding bearing way, but in some instances a bearing way or other device might be located between the precision parallel device/preload fixture and the bearing way.

In any of the examples describe above, the preload fixture contains the necessary features to provide appropriate preload on the bearing assemblies to remove undesirable freeplay. The precision of the preload fixture and the precision parallel device is such that they serve to accurately locate and align the bearing assemblies on the base and the slide plate. Once the bearings are located, aligned and preloaded using the fixture and device,

they are secured in place via the fasteners (or by other means). The clamping force of the bearing fasteners maintains bearing location and thus maintains the preload and precision alignment of the bearing assemblies.

The end result is a linear table assembly with properly preloaded and/or aligned bearing assemblies - without the need for integral bearing locating shoulders and/or preload devices. Elimination of the shoulders and/or preload features simplifies the design of the linear table, and reduces the tolerances necessary for the plate, base and bearing assemblies. The table can also be narrower, as the bearing ways can be located against the side edges, and there is no additional width necessary to support locating shoulders.

The linear table, and the method described above is thereby accurate, simplified, and relatively easy, so that the linear table has smooth and precise operation. The linear table requires fewer screws than in known prior designs, and specifically, does not require "pre-load screws", as the preload is a function of the controlled movement of the fixture jaws. The linear table also does not require shoulders, as the alignment of the bearing assemblies is accomplished with the precision parallel device. As such, the manufacture of the table is simplified, and manufacturing and assembly is facilitated. The risk of misalignment is also reduced.

The principles, preferred embodiments and modes of operation of the present invention have been described in the foregoing specification. The invention which is intended to be protected herein should not, however, be construed as limited to the particular form described as it is to be regarded as illustrative rather than restrictive. Variations and changes may be made by those skilled in the art without departing from the scope and spirit of the invention as set forth in the appended claims.